BELLCOMM, INC.
955 L'ENFANT PLAZA NORTH, S.W. WASHINGTON, D. C. 20024

B68 11096

SUBJECT: Pre-TLI Navigation and Command Passes for Lunar Missions - Case 310

DATE: November 29, 1968

FROM: T. B. Hoekstra

ABSTRACT

The ability of the Manned Space Flight Network Unified S-Band stations to satisfy tracking and command requirements prior to translunar injection (TLI) on lunar missions has been analyzed.

The command pass requirement (a pass over a station having command capability within some specified time period before TLI) is more difficult to satisfy than is the tracking pass requirement (one or more tracking passes within some time period before the command pass) for the range of coverage times generally considered because the time period in which it must fall is generally more restricted than is the time period for the tracking pass(es).

In addition, the preference for Atlantic or Pacific injections has been examined. There is a preference for Pacific injections if the command pass is required between 90 and 30 minutes prior to TLI. As the acceptable time period for the command pass is moved closer to TLI, the coverage provided by United States stations gives rise to a strong preference for Atlantic injections. The preference for Atlantic injections in this case is especially strong if the TLI ship is not located for good command coverage in the Indian Ocean or if the command capability of the TLI ship is simply not used.

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MEMORANDUM FOR FILE

An analysis has been made of the ability of the present Manned Space Flight Network Unified S-Band (USB) stations to satisfy the requirements for tracking passes while the spacecraft is in parking orbit prior to translunar injection (TLI). There is a requirement for a command pass within some time period referenced to the TLI ignition time in order to update the navigation state vector before TLI. At least one tracking pass is required prior to the command pass to provide the data transmitted during the command pass. The tracking pass(es) must fall in some time period referenced to the command pass.

A detailed analysis has been made of the satisfaction of three possible command pass requirements and then the current command requirement is combined with two possible tracking pass requirements to give an overall view of pre-TLI tracking and command capability.

The following three possible command pass requirements have been examined:

(1) a command pass is required in the 60 minute period between 90 and 30 minutes before TLI (the requirement appearing in the March 15, 1967 Joint Reference Constraints Document),

(2) a command pass is required in the 35 minute period between 45 and 10 minutes before TLI (the revised requirement as it will appear in the new Joint Constraints Document),

(3) a command pass is required in the 20 minute period between 28 and 8 minutes before TLI (the requirement according to MSFC Lunar Landing Mission Launch Vehicle Ground Support Plan, Issue 1, #I-MO-5-67, October 1967).

The 14 USB land stations (Merritt Island, Grand Bahama Island, Bermuda, Antigua, Canary Island, Madrid, Ascension, Carnarvon, Canberra, Guam, Hawaii, Goldstone, Guaymas, and Texas) and two tracking ships (an Insertion ship and an Injection ship) have been considered. A 3 minute pass was considered sufficient

for command and a 4 minute pass was specified for tracking. The spacecraft was assumed to be acquired at an elevation angle of 5° and lost when the elevation angle decreased to 3°. All land stations were assumed to have 15° keyholes except Bermuda which was assumed to have 6° keyholes.

The shaded and crosshatched areas in Figures 1, 2, and 3 show the regions in azimuth and time in which TLI should not occur if the three pre-TLI command requirements defined above are to be met by the 14 land stations and the Insertion ship. The crosshatched areas on these figures disappear if an Injection ship is used (located at 48°E, 25°S).

The time-azimuth regions in which 2nd and 3rd revolution Atlantic and Pacific injections occur are indicated in these figures. The lower boundaries for the Atlantic injection regions are determined by the TLI times for missions flown (arrival) when the moon is at southern lunstice; the upper boundaries for the Atlantic regions are determined by northern lunstice TLI times. For Pacific injections, these boundaries are interchanged.

The requirement for a command pass between 90 and 30 minutes before TLI ignition gives a preference for Pacific injections as shown in Figure 1. Figure 2 shows that revising this to a requirement for a command pass between 45 and 10 minutes before TLI changes the preference to Atlantic injections if the TLI ship is not used. If the TLI ship is used (48°E, 25°S), there is only a slight preference for Atlantic injections. If the requirement for a command pass between 28 and 8 minutes before TLI were adopted, Atlantic injections would be preferred with or without the TLI ship as shown by Figure 3. The shift from a preference for Pacific injections to Atlantic injections as the time period for the command pass moves toward TLI is a result of the excellent coverage available during passes over the United States. Atlantic TLI's occur within about a half hour of the end of the pass over the United States and it follows that Atlantic injections almost automatically satisfy a requirement for a command pass in the half hour before TLI.

In addition to the requirement for the pre-TLI command pass, there is a requirement for tracking passes during the earth parking orbit phase of the mission prior to the command pass. The following example is the first of two which were examined in detail:

(1) Assume a command pass is required between 45 and 10 minutes before TLI ignition,

(2) assume 2 four-minute tracking passes are required in the 90 minute period which ends 10 minutes before the pre-TLI command pass (at least one of these tracking passes must be from a land station).

The shaded regions in Figure 4 represent azimuth-time areas in which, if TLI ignition should occur, the above requirements are not met (the TLI ship coverage has been included in this analysis). It should be noted that most of the shaded regions in Figure 4 are identical to those in Figure 2 which indicates that the requirement for 2 tracking passes prior to the command pass is a more easily satisfied constraint than is the command pass requirement. When the TLI ship is used for command and tracking, the only large problem area is for 2nd revolution Atlantic injections (1st Atlantic opportunity) with launch azimuths between 104° and 108°.

The second example which was examined in detail involved the following assumptions:

(1) A command pass is required between 45 and 10 minutes before TLI ignition,

(2) one four-minute tracking pass is required in the 70 minute period which ends 10 minutes before the pre-TLI command pass (this tracking pass must come from a land station).

The shaded regions in Figure 5 represent azimuth-time areas in which if TLI ignition should occur the above requirements are not met. Again in this case the shaded regions in Figure 5 are almost identical to those in Figure 2.

Conclusions

It can be concluded that there are some regions (in azimuth vs. TLI time) in which the available tracking does not satisfy the requirements. The preferred ocean for injection is the Pacific if the pre-TLI command pass is required between 90 and 30 minutes before TLI ignition. If the pre-TLI command pass is required between 45 and 10 minutes before TLI, the Atlantic is preferred if the TLI ship is not located for good command coverage in the Indian Ocean or is simply not used for command. There is essentially no preference for Atlantic or Pacific if the TLI ship is used. For command in the 28 to 8 minute period prior to TLI, Atlantic injections are preferable, even if the ship coverage is used, due to the thorough coverage from the pass over the United States.

T. B. Hoekstra

2013-TBH-srb

T. B. Hoekstra

Attachments

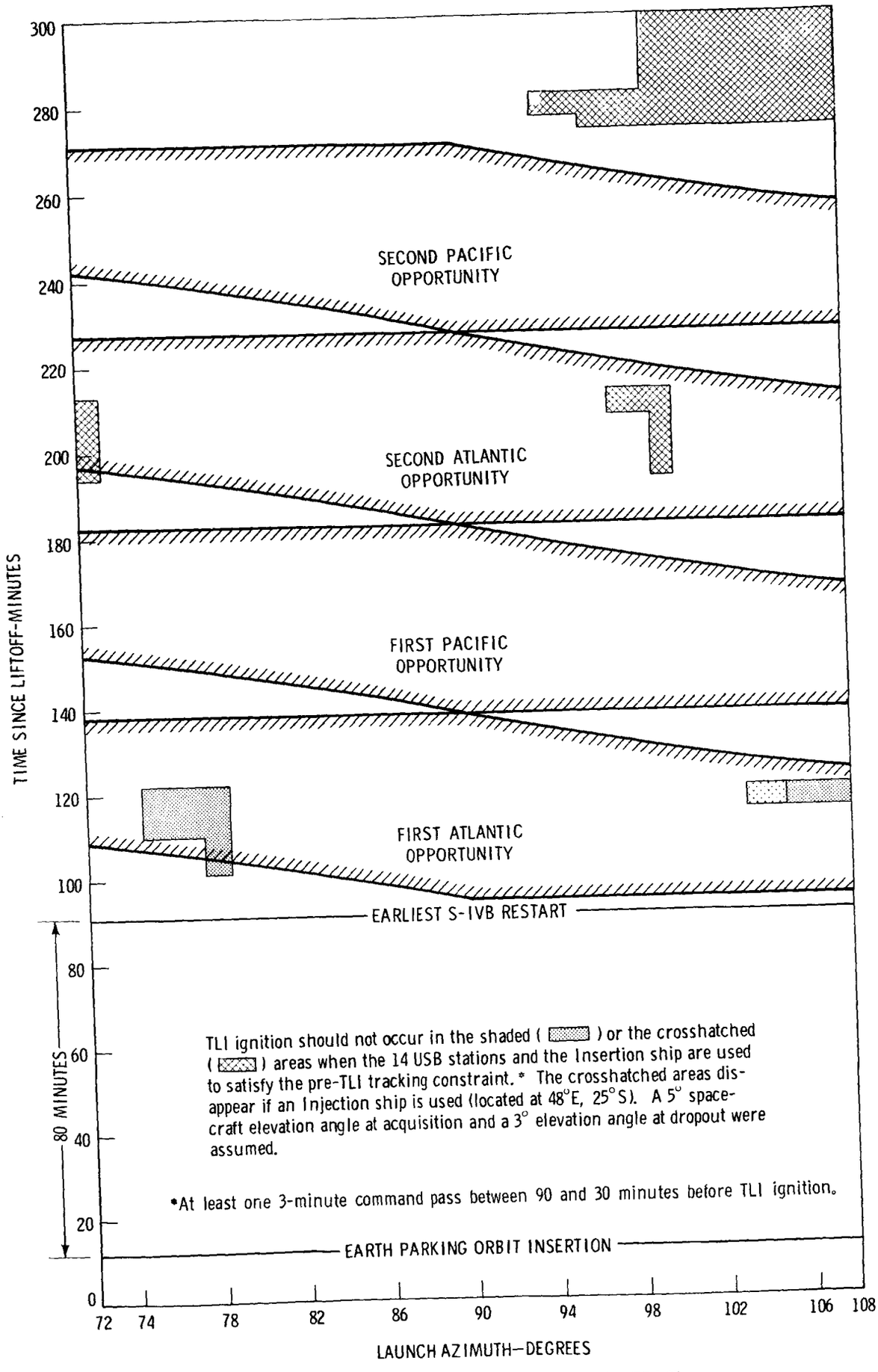

FIGURE 1 - PRE-TLI COMMAND PASS COVERAGE

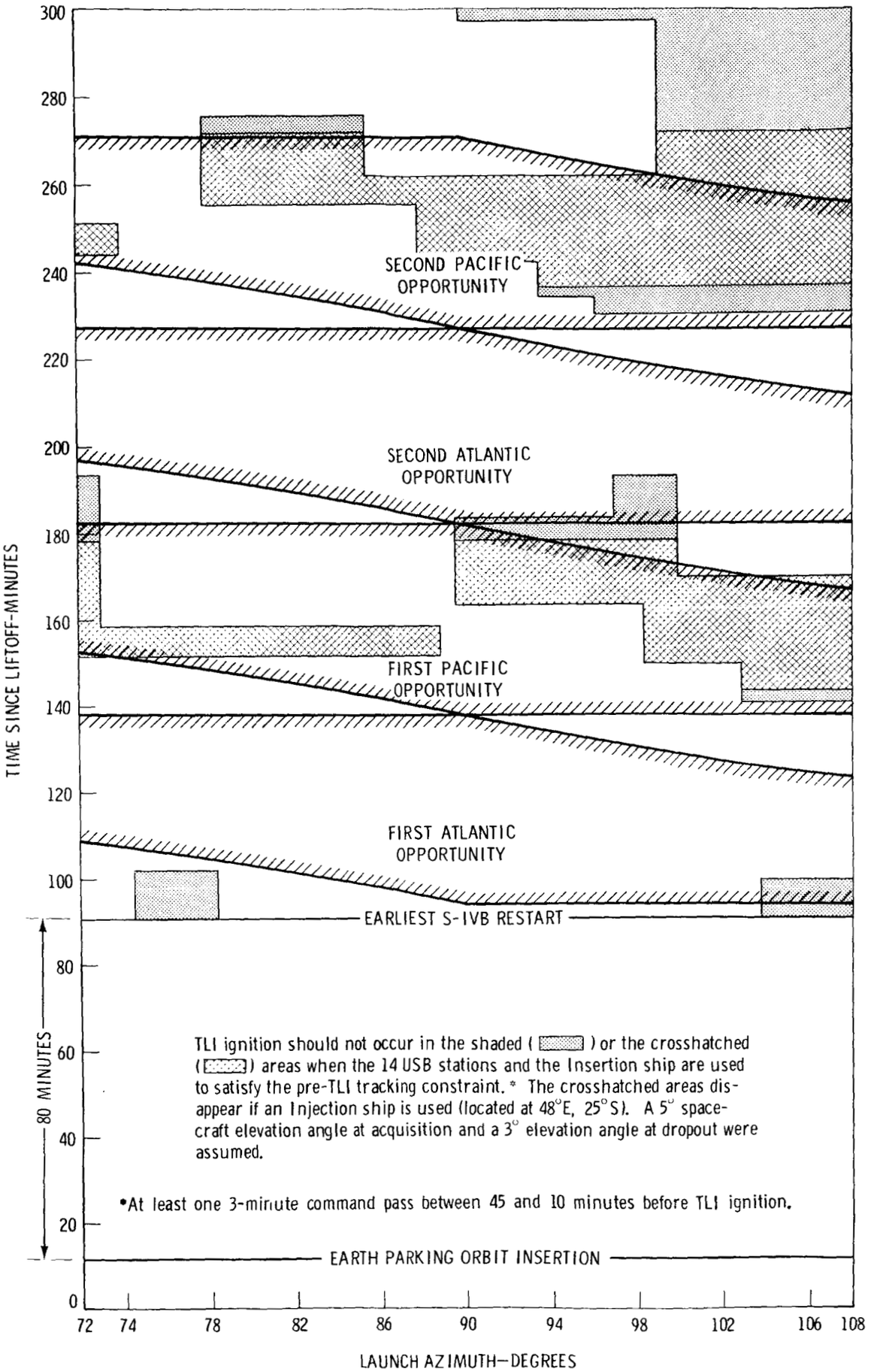

FIGURE 2 - PRE-TLI COMMAND PASS COVERAGE

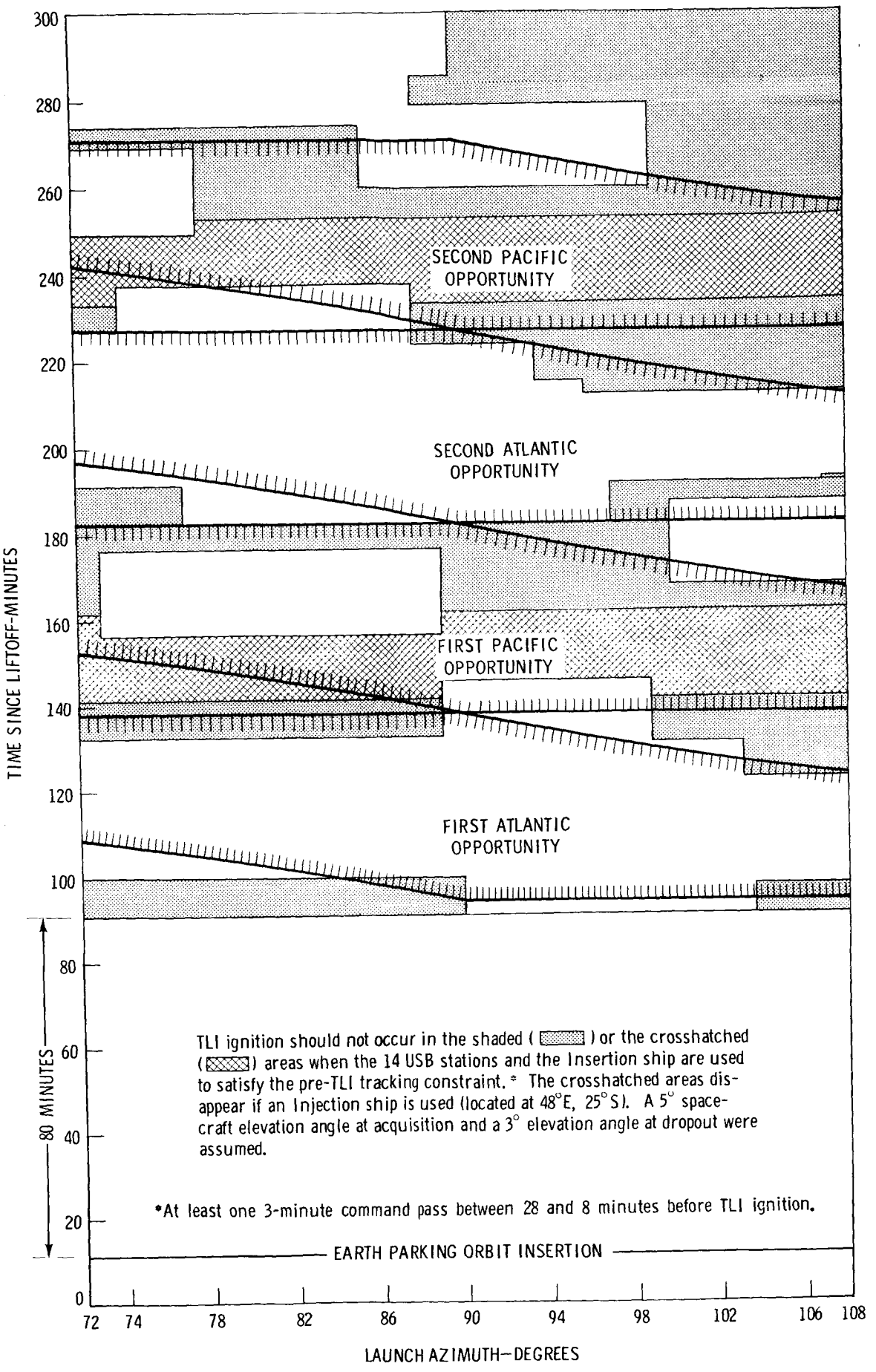

FIGURE 3 - PRE-TLI COMMAND PASS COVERAGE

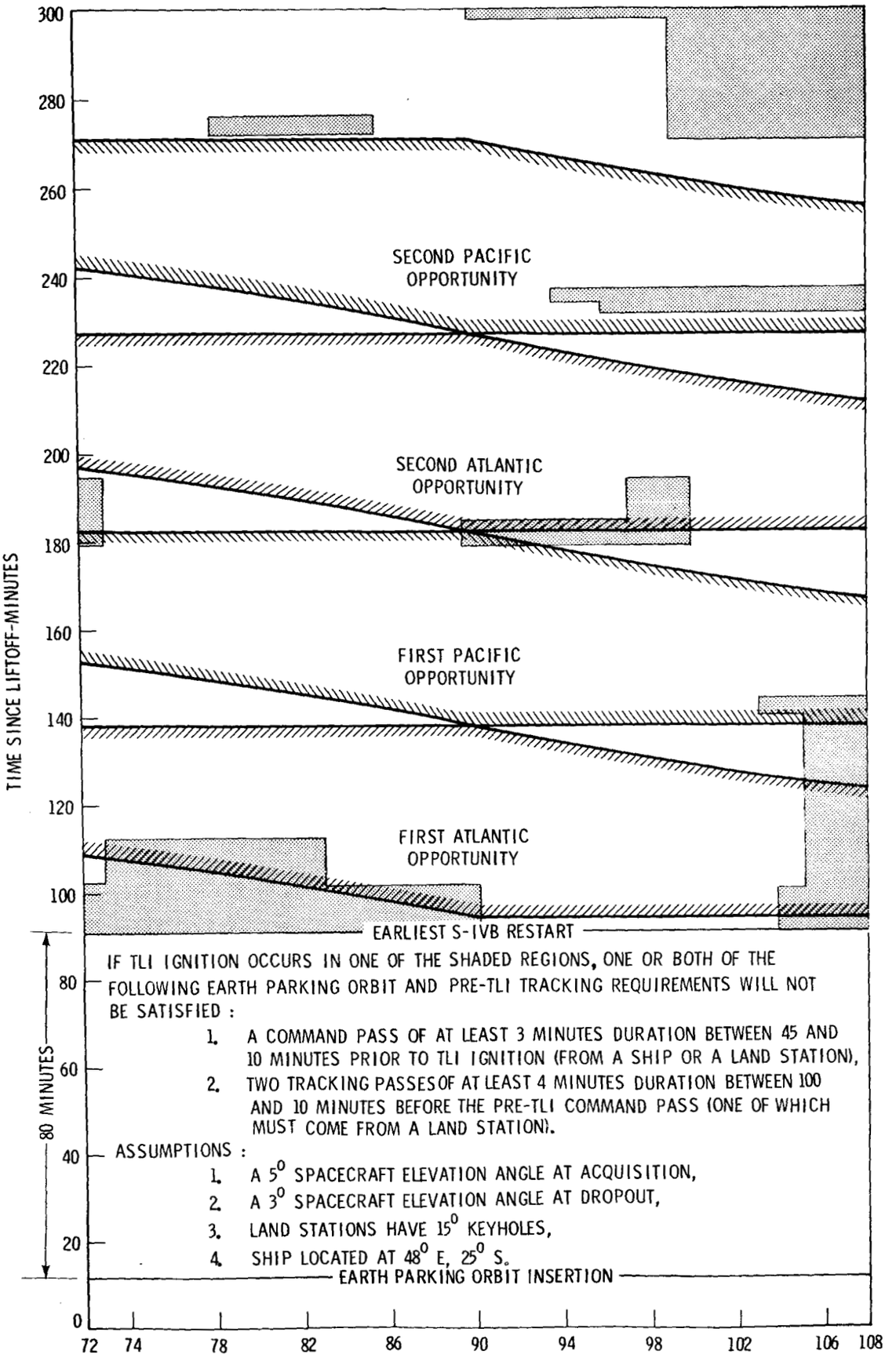

FIGURE 4 - PRE-TLI COMMAND AND TRACKING PASS COVERAGE

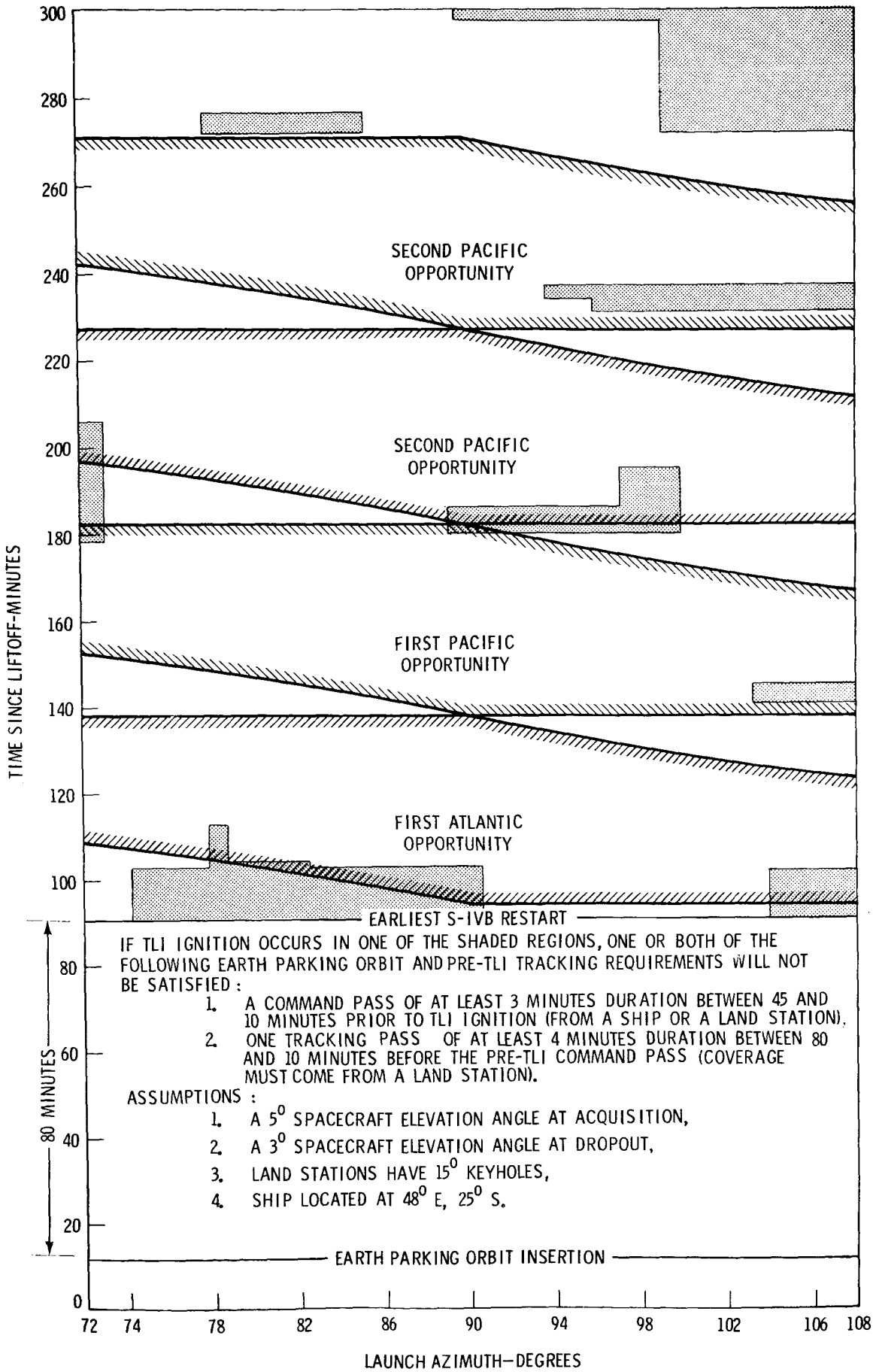

FIGURE 5 - PRE-TLI COMMAND AND TRACKING PASS COVERAGE

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